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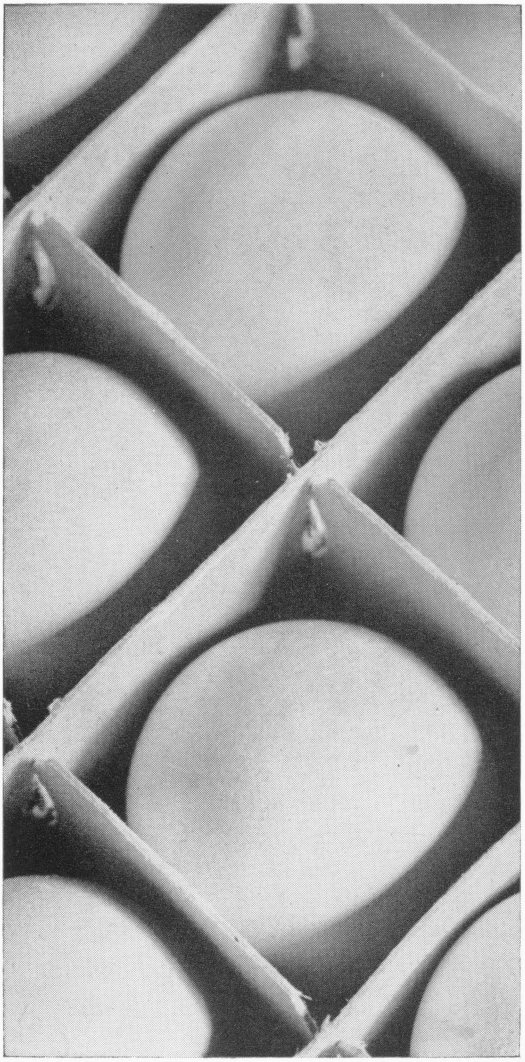

CLEANING EGGS with detergents and detergent-sanitizers

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CLEANING EGGS WITH DETERGENTS AND DETERGENT-SANITIZERS

A. R. WINTER, BLANCHE BURKART, PATRICIA CLEMENTS and LOIS MacDONALD

INTRODUCTION

Ten to 25 percent of the eggs produced under average farm conditions are soiled at time of gathering according to a review of the literature by Winter, Burkart and Wettling (1952). Under poor management conditions the percent may be much higher as pointed out by Walker and Bressler (1954). Even under good management conditions such as the maintenance of dry litter, an adequate number of clean nests and frequent gathering of eggs, one may expect to obtain 5 to 10 percent soiled eggs as shown by Funk, Kempster and Dandy (1950).

Soiled eggs sell for 10 to 40 cents per dozen less than clean eggs on markets where eggs are sold on grades as shown by market quotations from the Northwestern Ohio Poultry Association and reported in a North Central Regional Publication (1953). As long as this price differential exists, poultrymen will clean eggs.

The cleaning time required per case of eggs varies from 14 to 65 minutes with an average of 33, depending on the amount of dirt or stain to be removed, the color of the shells, the cleaning method and the labor saving devices used, as shown by Walker and Bressler (1954). The cleaning and packaging of eggs require about 33 percent of the total time required for commercial egg production according to Bressler (1952).

Wet cleaning methods have proven to be more desirable than dry ones as shown by data published by Funk (1948) and Winter et al. (1952). They result in a saving of labor, less breakage, more thorough cleaning and less spoilage, if a sanitizer is used. Until recently, water alone was most widely used for the wet method of cleaning eggs. Now, a number of detergents, combination detergent-sanitizers and sanitizers are being recommended for use in the water.

REVIEW OF THE LITERATURE

Jenkins et al. (1920) cleaned eggs by washing in water and dilute sulfuric acid. Spoilage ranged from 6.6 percent among the unwashed controls to 14.4 percent when washed in water, the eggs were held in cold storage 6 to 11 months.

Bryant and Sharp (1934) washed 6 to 12 soiled eggs in each of the following solutions and held them at room temperature for about a month: water, N/10 sulfuric acid, N/10 sodium hydroxide, water glass (1:12), soap (5 grams in 3 liters), Wyandotte powder (strong solution), sapolio (wet and dusted), and sodium hypochlorite solution (1:100). The eggs did not keep well. Clean eggs washed in similar solutions kept satisfactorily.

Funk (1938) reported better keeping quality of eggs held in cold storage when washed in 0.5 to 1.0 percent sodium hydroxide solution than when washed in 70 percent alcohol or in a 0.15 percent solution of a chlorine compound (available chlorine content not listed). He observed that washing eggs in sodium hydroxide solution did not impair their functional properties. The bacterial content of the egg pulp from broken out eggs was reduced more than 50 percent by washing the eggs before breaking, in one percent sodium hydroxide solution (Table 8).

Zagaevsky and Lutikova (1944) reported that washing eggs in 0.5 percent chlorinated lime (available chlorine not listed) solution and keeping them in it for 5 minutes reduced the bacterial content of the pulp from 200,000 to 30 per ml.

Penniston and Hedrick (1944) (1945) 1947) reduced the bacterial content per egg shell from more than 5 million to less than 300,000 by washing the eggs in a detergent—germicide (Emulsept) solution. Washing soiled eggs in a detergent-sanitizer before breaking them resulted in a reduction of bacteria in the pulp from more than 1,000,000 to about 3000 per ml. (Table 8).

Funk (1948) reported better keeping quality of washed soiled eggs held in cold storage when washed in a detergent-sanitizer than in water. The average spoilage was 23.5 percent when washed in water, 10.2 percent when washed in 1 percent sodium hydroxide, 4.7 in Roccal (10 percent) ½ ounce per gallon, and 3.7 percent in Kleneg (0.7 oz. per gal.) and rinsed in Saneg (0.2 oz. per gal.)

Williams and Goble (1949) washed artificially soiled eggs in Dreft (37 grams in 3 gal.). They did not spoil while held in cold storage.

Gillespie et al. (1950) washed soiled eggs in water, hypochlorite solutions, formalin, Fixanol and sodium hydroxide and held the eggs 6 to 8 weeks at room temperature. A high level of chlorine (5000 p.p.m.), 0.1 percent Fixanol and 1 percent formalin reduced spoilage.

Pino (1950) washed lots of 100 clean and soiled eggs, the day gathered, in an anionic detergent-sanitizer, Nocconal N R, and held them 4 weeks at 60° F. There was no spoilage among the washed eggs.

Miller et al. (1950) washed soiled eggs in water containing black rot bacteria and dipped part of them in sanitizers, 1 percent Roccal and 0.5 percent pentachlorophenol. The sanitizers reduced spoilage a little. Five minutes exposure of the wash water to 1 percent Roccal reduced the baterial content from several million per ml. to zero.

Starr, et al. (1952) observed no difference in the keeping quality of eggs washed in warm water or an alkaline detergent, 2 percent trisodium phosphate. Lorenz et al. (1952) observed that the keeping quality of eggs from ranches was better when washed in trisodium phosphate, an anionic detergent or Clorox than in water alone.

Winter et al. (1952) observed better keeping quality of eggs washed in a detergent-sanitizer (Emulsept) than in a detergent (Vel) or water. (Tables 9 and 10).

Forsythe et al. (1953) removed 82 percent of the bacteria from shell eggs by washing in 0.5 percent Vel, 93 percent by Roccal (200 p.p.m.) and 93 percent by 0.5 percent Kleneg. (Table 7).

Botwright (1953) reported that very few of the detergent-sanitizers on the market cleaned eggs satisfactorily unless they contained a quarternary ammonium compound combined with an alkaline detergent. Acid detergent-sanitizers were used up quickly by the alkaline shell. Hyamine 2389 was an effective germicide against Pseudomonas bacteria which frequently cause green rot in washed eggs.

Druchery (1953) compared the cleaning efficiency and keeping quality of eggs washed in water, acid and alkaline detergents and acid and alkaline detergent-sanitizers. Best results were obtained with the alkaline detergent-sanitizers. (Tables 9 and 10).

Miller (1954) washed soiled eggs in water, 1 percent sodium hydroxide, a detergent followed by rinsing in Roccal (1 oz./4 gal.), lactic acid (2 percent), and sodium bisulfite (1 percent) + hydrochloric acid to liberate sulfur dioxide. None of the washing procedures reduced the percentage of egg contents contaminated with egg spoilage bacteria.

OBJECTIVES

In recent years a number of new detergents, combination detergents and sanitizers (detergent-sanitizers) and sanitizers have been placed on the market for cleaning and sanitizing equipment in food and dairy plants. Some of them have been advocated for cleaning eggs. Some special detergent-sanitizers have been formulated and sold for this purpose. Poultry producers, egg marketing firms, cold storage plant operators, frozen and dried egg processors, public health officials, bakers and consumers have requested information on detergents, detergent-germicides and sanitizers for washing eggs and their effects on keeping quality, wholesomeness and functional properties of the washed eggs.

The objectives of this study have been to obtain data on the following when detergents and detergent-sanitizers are used for washing eggs:

1. Cleaning efficiency
2. Concentration
3. Number washed
4. Temperature
5. Soaking
6. Machines
7. Bacteria in eggs
8. Keeping quality
9. Functional properties

PROCEDURES

Eggs. Naturally soiled eggs (more than 20 percent of the surface soiled or stained) were used for the tests unless otherwise stated. They were obtained from baskets of eggs gathered on the university poultry farm. The soiled eggs were held until a sufficient number were obtained to conduct a test. This usually required a week, but sometimes as long as two weeks. The eggs were held in an egg room at 55° F. and 66 percent relative humidity.

Calculation of cleaning efficiency. Each egg was numbered or given a definite location on a flat so that it could be located at any time in the cleaning and drying process. The percentage of the shell surface soiled or stained before and after cleaning and drying was estimated and recorded for each egg. Wet eggs were placed in a wire basket and dried for one hour in front of a fan. The percent cleaning efficiency was calculated as follows:

$$\text{Cleaning efficiency (Percent) (Dirt and stain removed)} = \frac{\text{Percent of shell surface soiled before cleaning} - \text{Percent of shell surface soiled after cleaning}}{\text{Percent of shell surface soiled before cleaning}} \times 100$$

CLEANING EFFICIENCY

Cleaning efficiency of detergents and detergent-sanitizers were compared when eggs were hand and machine washed, soaked and not soaked before washing, washed in two different strengths of solution and washed at different temperatures.

DETERGENTS

Hand washing. Detergent solutions were prepared in 3 gallon earthenware jars in tap water at 100° F. to 110° F. Two gallons of cleaning solution were prepared. Two dozen soiled eggs, previously selected at random and classified for degree of soil, were placed in the solutions in the jars. After soaking 10 minutes they were washed by rubbing with a rag until all the dirt and stain that would come off easily were removed. The eggs were dried and classified for dirt or stain remaining on the shells as previously described. The data have been summarized in Table 1, trial 1. The cleaning efficiency of water was improved 10 to 15 percent by adding a detergent. The use of 1 ounce per gallon of water improved the cleaning efficiency about 5 or 6 percent over the use of ½ ounce per gallon. While the detergents removed the dirt easily, they did not remove all of the stain. Consequently, after cleaning, some of the shell surfaces still showed stain marks.

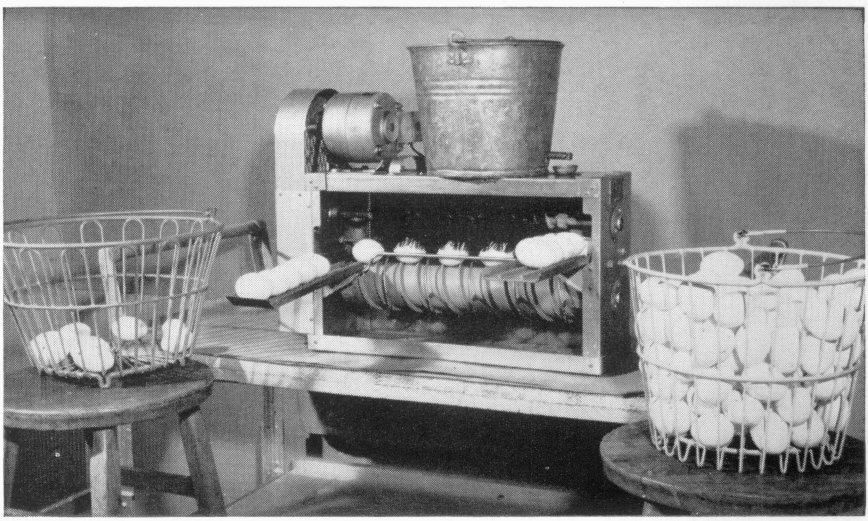

Fig. 1.—A brush-type egg washer used for evaluating cleaning efficiency of detergents and detergent-sanitizers. Front panel removed to show inside of machine.

TABLE 1.—Cleaning and sanitizing efficiency of detergents and detergent-sanitizers

Products*	Cleaning Efficiency (percent)							Rots. All trials
	Trial 1		Trial 2		Trial 3		All machine cleaned	
	Hand Washed		Machine Washed		Machine Washed			
	1 oz./gal.	½ oz./gal.	1 oz./gal.	½ oz./gal.	½ oz./gal.			
					Not soaked	Soaked	Average	Percent
Clean, control	—	—	—	—	—	—	—	1
Soiled, control	—	—	—	—	—	—	—	4
Water	55	55	45	45	63	74	57	17
Detergents:								
Trisodium phosphate	79	70	56	50	70	93	67	33
Calgon	79	70	67	55	65	82	67	17
D-40	56	53	39	39	75	73	57	25
Santomerse	72	68	53	57	50	—	53	13
Dreft	—	—	—	—	—	74	—	40
Vel	76	--	59	—	—	—	—	19
Sodium metasilicate	72	67	55	56	69	96	69	18
Average	72	66	55	51	66	84	63	24

TABLE 1.—Cleaning and sanitizing efficiency of detergents and detergent-sanitizers—Continued

Products*	Cleaning Efficiency (percent)							Rots. All trials
	Trial 1		Trial 2		Trial 3		All machine cleaned	
	Hand Washed		Machine Washed		Machine Washed			
	1 oz./gal.	½ oz./gal.	1 oz./gal.	½ oz./gal.	½ oz./gal.			
					Not soaked	Soaked	Average	Percent
Detergent-sanitizers:								
Clorox†	93	—	61	—	89	94	81†	17
Lye	73	77	56	56	35	91	60	27
Salute	88	76	61	60	50	89	65	21
KDS-1	74	76	51	54	61	96	66	22
Kromet	72	68	51	52	71	85	65	26
No. 5	80	73	58	58	56	93	66	15
Kleneg	76	74	61	59	80	92	73	30
Tri-bac	69	66	47	51	80	88	67	23
Emulsept	49	44	39	40	50	53	46	21
Diokem	68	57	53	53	69	88	66	28
Ahcogent	58	64	35	45	82	88	63	31
KCD-1	—	—	—	—	—	92	—	36
Thermosan	54	53	35	36	51	—	41	20
Sanisuds	55	51	45	42	60	—	49	42
Average	70	65	50	51	64	88	62	26

*See page 65 for description of products.

†Used at rate of 6 oz. per gallon.

Machine washing. Two dozen, randomized soiled eggs per treatment were washed in a small brush-type egg washer (Fig. 1), by passing them through the machine once with the cleaning solution draining from the bucket into the washer. The data have been summarized in Table 1, trial 2. The machine washing was not as efficient as hand washing. The machine washed eggs were not pre-soaked in trial 2 while they were in trial 1, where washed by hand. The machine rubbed the eggs a constant time and under constant pressure. In hand washing the pressure applied and the time of rubbing varied with the amount of dirt or stain to be removed. The higher concentration of cleaning solution resulted in slightly greater cleaning efficiency by detergents when eggs were machine cleaned without soaking. In trial 3 half of the eggs were soaked 10 minutes before machine cleaning while the others were not. Soaking increased the cleaning efficiency about 18 percent.

The cleaning data obtained with machine cleaning (trials 2 and 3) have been combined and reported to the right of trial 3 in Table 1. The data are based on 96 eggs per treatment.The addition of 5 of the 7 detergents tested improved the cleaning efficiency of water. Sodium metasilicate, trisodium phopshate and Calgon gave the best results. Trisodium phosphate and Calgon were more efficient when used at a level of 1 oz. than at ½ oz. per gallon in Columbus water (5 grains per gallon).

DETERGENT-SANITIZERS

Hand washing. Thirteen detergent-sanitizers were tested in the same manner and at the same time as the detergents, previously described. Their cleaning efficiency was about the same as that of detergents, (Table 1, trial 1). The use of 1 ounce per gallon resulted in about 5 percent greater cleaning efficiency than the use of ½ ounce per gallon.

Machine washing. The same procedures were used as in machine washing with detergents (above). Machine washing was more efficient when the eggs were soaked in the solutions before cleaning. The cleaning efficiency of the detergents and detergent-sanitizers was about the same when machine tested.

Machine cleaning followed by hand cleaning. Soiled eggs were soaked 10 minutes in detergent-sanitizer solutions (½ ounce per gallon) for 10 minutes; washed in the machine (Fig. 1); classified for cleanliness; and then rubbed by hand with some of the same cleaning solution

until all of the easily removable dirt and stain were washed off. The average time required to complete the washing by hand was recorded. The data have been summarized in Table 2.

Clorox rated among the best, at the concentration used for cleaning purposes (Tables 1 and 2). The chlorine was effective in the removal of stains. Kleneg, a detergent-sanitizer, especially formulated for cleaning eggs, was also among the most effective egg shell cleaners (Tables 1 and 2), while Thermosan was the poorest, under the conditions tested.

Different types of egg washers. A detergent-germicide (No. 115) described by Botwright (1953) and recommended for egg cleaning and sanitizing was used for hand and machine washing of eggs. It was used at a strength of ½ ounce per gallon of water. Six to 8 dozen soiled eggs, randomly selected per treatment per trial were used. Three trials were conducted.

Hand washing (control) (Fig. 2). A basket of eggs was placed in a tub of the detergent-germicide at 100° F. – 110° F.; soaked 10 minutes; and the dirt and stain rubbed off with a cloth.

Bubbler washer (Fig. 3). Eight gallons of solution was prepared in the washer and the temperature adjusted to 120° F. The basket of eggs was placed in the washer and washed 4 minutes. One basket was washed and not rinsed. Another one was washed and hosed off with warm water after removal from the washer.

TABLE 2.—Cleaning efficiency of detergent-sanitizers and keeping quality of the cleaned eggs

Treatment*	No. of eggs	Cleaning		Keeping Quality		
		Efficiency	Time per egg	Rots	Stuck	Grade decline
		Percent	Seconds	Percent	Percent	Percent
Clean, control	44	—	—	0	11	63
Soiled, control	43	—	—	1	2	66
Clorox†	52	49	7	8	35	66
KDS-1	44	51	7	11	27	67
KDS-3	36	46	7	8	33	67
Kleneg	38	56	6	5	24	66
Emulsept	52	52	7	0	21	65
Thermosan	56	44	11	2	30	66

*See appendix for description of compounds used.

†Used at the rate of 6 oz. per gallon.

Fig. 2.—Method of soaking and hand washing eggs.

TABLE 3.—Cleaning efficiency of three different type egg washing machines

Treatment	No. of eggs	Cleaning efficiency (percent)
Hand washed, rinsed	292	88
Bubbler washer (Fig. 3):		
Not rinsed	296	62
Rinsed	292	68
Rotating spray washer:		
Not rinsed	294	57
Rinsed	291	60
Conveyor brush washer and dryer:		
Soaked 4 min. (No. 115)	295	92
Not soaked (No. 115)	210	88
Not soaked. Water	210	84

Rotating spray washer (Fig. 4). The same amount of solution and the same procedure was followed as with the bubbler washer.

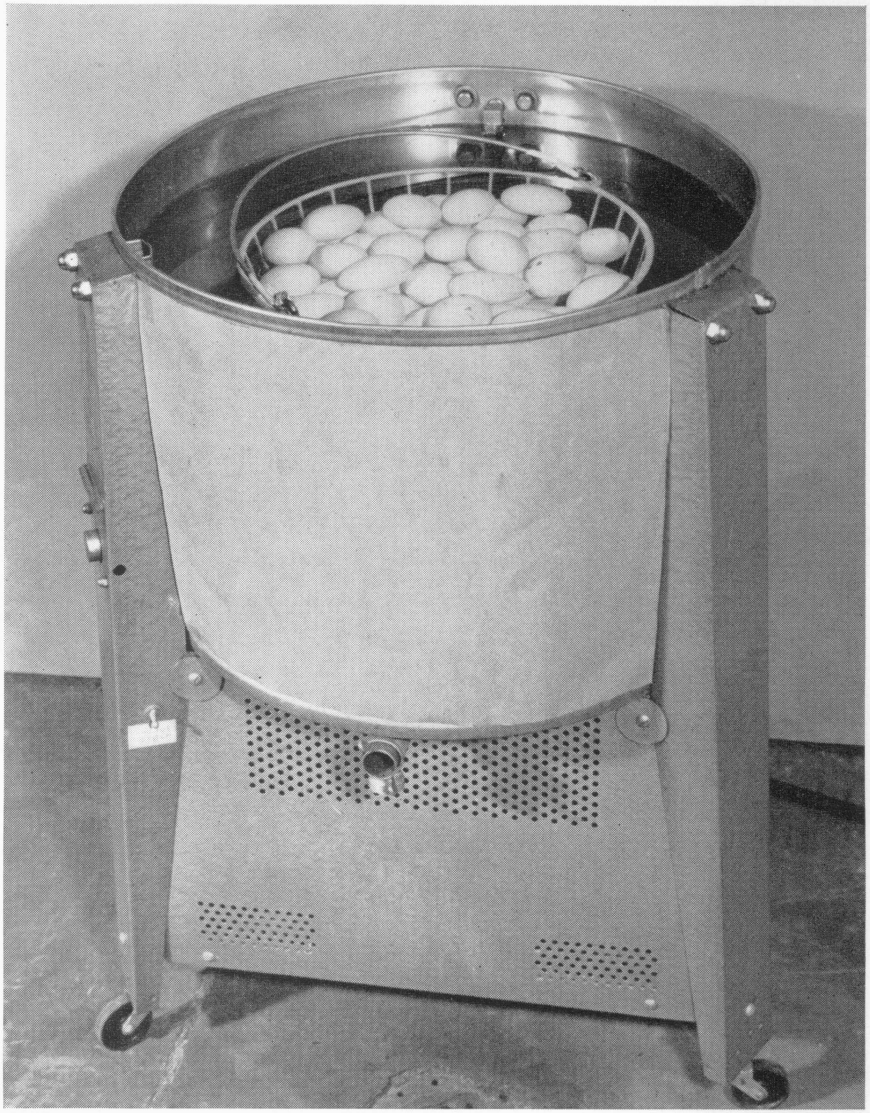

Fig. 3.—A bubbler type egg washer.

Fig. 4.—Lifting a basket of eggs from a rotary spray type washer.

A brush washer and dryer (Fig. 5). A bucket of the cleaning solution was attached to the washer and allowed to flow into it by gravity. A basket of eggs was washed by passing them through the washer, after soaking them in the cleaning solution 10 minutes; another basket without previous soaking; and, still another one without soaking and with water instead of cleaning solution used in the machine.

The data obtained with hand and the three types of machine washing have been summarized in Table 3. The bubbler and spray type washers, where no rubbing was applied did not clean eggs as thoroughly as where rubbing was applied either by hand or machine. The spray and bubbler type machines created much foam when the detergent-germicide (No. 115) was used. Straw, feathers and other light material were suspended in the foam on the surface. When the basket of eggs was lifted out, some of the material stuck to the eggs. Consequently, the cleaning efficiency was improved a little when the baskets of washed eggs were hosed off with warm water.

The conveyor brush and drier type of egg washing machine (Fig. 5) cleaned eggs just about as efficiently as when they were washed by hand. As in previous trials, the cleaning efficiency of water was improved a little by adding the detergent-germicide and soaking the eggs increased the cleaning efficiency still more.

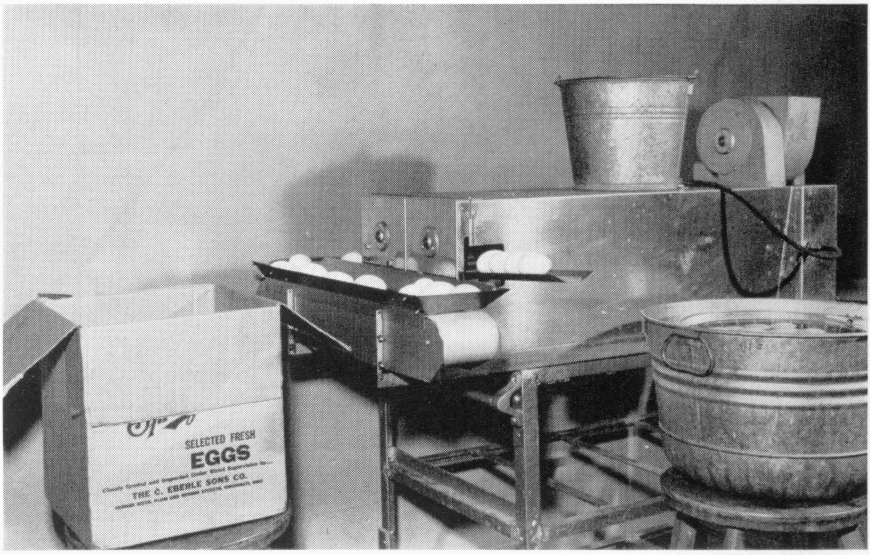

Fig. 5.—Conveyor brush type egg washer equipped with dryer. Cleaning efficiency improved by pre-soaking eggs (tub at right) and use of detergent-sanitizer solution (bucket on top of machine) in place of water for washing eggs.

Maintenance of strength of detergent-sanitizer solutions. Successive lots of 10 dozen eggs each were washed in the bubbler type washer containing 8 gallon of No. 115 solution (250 ml. per egg and ½ oz. per gal.). The data have been summarized in Table 4 and Figure 6. The cleaning efficiency decreased as the number of eggs washed increased. The drop was rapid after the third 10 dozen lot had been washed. Approximately 4 dozen eggs could be washed per gallon of solution (½ oz./gal.). The data are in agreement with that of Botwright

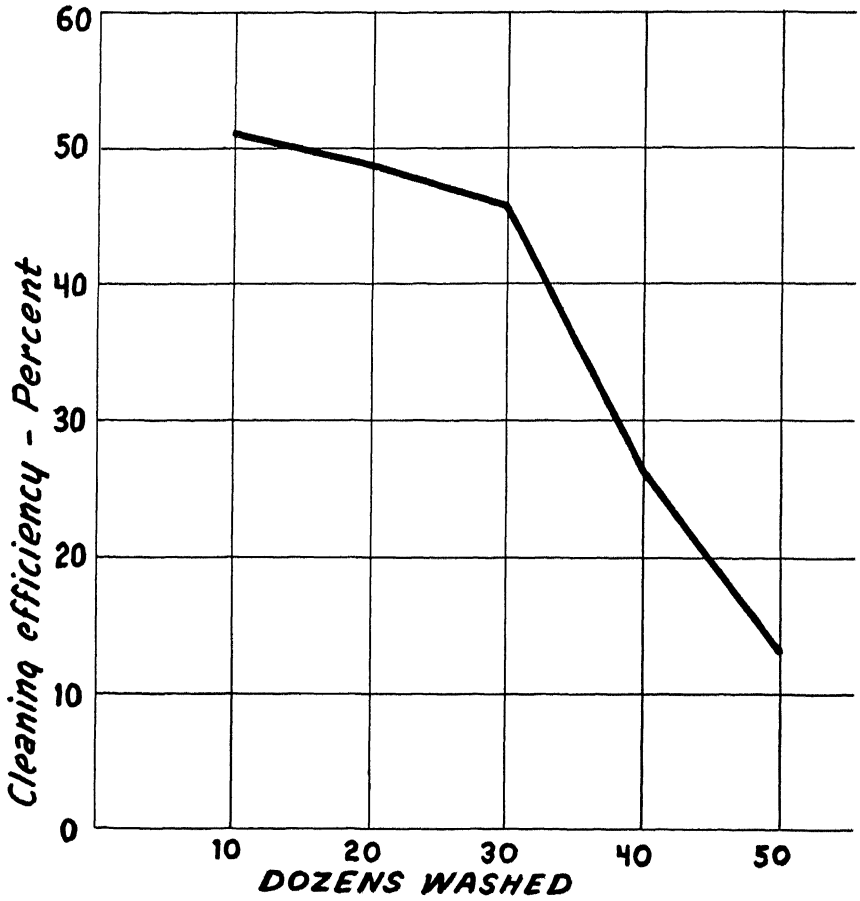

Fig. 6.—Decline in cleaning efficiency with each 10 dozen soiled eggs washed in 8 gallon of #115 detergent-sanitizer (0.3%).

TABLE 4.—Efficiency of detergent-sanitizers (No. 115) for washing successive numbers of eggs

Number washed	Cleaning Efficiency (2 trials)		
	Average	High	Low
1st. 10 doz.	51	58	43
2nd. 10 doz.	49	53	45
3rd. 10 doz.	46	52	39
4th. 10 doz.	26	42	10
5th. 10 doz.	12	22	2

(1953) who found that the cleaning efficiency of No. 115 was lost before its germicidal power. The latter started to show rapid loss after 6 to 8 dozen were washed per gallon. Funk (1938) recommended 2 level teaspoons of lye in a gallon of water for washing 15 dozen eggs and replenishing the alkali if more eggs were washed. Penniston and Hedrick (1947) observed a decline in bactericidal efficiency of Emulsept cleaning solution after each lot of 12 dozen eggs were washed in six liters of solution.

BACTERIA DESTRUCTION

A bubbler type egg washer (Fig. 3) was cleaned; 8 gallons of cold tap water added; the machine turned on 4 minutes; and the water sampled for bacterial analysis. Ten dozen eggs were washed in a wire basket in the bubbler egg washer and the water sampled again. Similar baskets of clean and soiled eggs were washed in cold and hot (120° F.) water. Soiled eggs were washed in cold and hot water and in cold and hot detergent-germicide (AFCO2626) solution containing ½ ounce per gallon. The AFCO2626 detergent-germicide was formulated to result in less foaming than No. 115, previously used in the bubbler washer. Bacterial analysis of the washing solutions, egg shells and egg meats were conducted according to the methods of the Association of Official Agricultural Chemists (1950).

The shells were placed in a sterile, tared Waring blendor jar; 9 times their weight of sterile saline solution added; the mixture blended for two minutes; and the supernatant solution analyzed for bacterial content. Dilution plates of the egg washing solution, shell washing

solution and egg meats were poured in duplicate on tryptone glucose extract agar and incubated at room temperature for 48 hours. The data obtained have been summarized in Table 5.

The washing solution. The bacterial content of a cold water egg washing solution before and after use should give a measure of the number of bacteria removed. If a procedure is used which results in fewer bacteria in the washing solution, one may assume that there are also fewer bacteria remaining on the egg shells.

TABLE 5.—Influence of washing 10 dozen eggs in 8 gallons of water on bacterial content of the wash water, shells and egg meat

Sample and Treatment	Standard Plate Bacteria (Log of Count)								
	Wash Water (per gm.)			Egg Shell (per gm.)			Egg Meat (per gm.)		
	Trial			Trial			Trial		
	1	2	3	1	2	3	1	2	3
Clean eggs:									
Wash water, before use	*<2	<2	2.2						
Eggs, before washing				3.8	4.1	4.2	<2		
Washed in cold water	<2	<2	<2	3.6	3.8	3.7	<2		
Washed in 120° F. water	<2	<2	<2	2.7	2.9	3.3	<2		
Soiled eggs:									
Wash water, before use	<2	<2	2						
Soiled eggs, before washing				TC†	5.5	5.4	<2	<2	<2
Washed in cold water	<2	<2	2.1	TC	4.2	6.0	<2	<2	<2
Washed in 120° F. water	<2	<2	2.3	2.9	5.0	6.7	<2	<2	<2
Soiled eggs:									
Detergent - sanitizer, ‡ before use	<2	<2	<2						
Soiled eggs				TC	5.5	5.4	4.3	4.2	3.0
Washed in cold solution	<2	<2	<2	4.6	4.5	3.3	3.5	2.7	2.4
Washed in 120° F. solution	<2	<2	<2	2.6	<2	2.3			

* < = Less than. No bacteria observed in 1 in 100 dilution.
†Too many to count at the highest dilution made.
‡AFCO 2626. 1 tablespoon per gal.

The bacterial content of the wash water in the machine before use ranged from 9 to 231 organisms per ml. with an average of 82, in 6 trials. The bacterial content of the cold wash water per egg washed, averaged 768,000 organisms (Tables 5 and 6). There were very few bacteria in the wash water when it was heated to 120° F. and the eggs washed 4 minutes. Gunderson and Gunderson (1945) reported that the higher the temperature of the egg washing water, between 130° F. and 180° F., the greater the destruction of bacteria in the solution and the fewer the number of bacteria remaining on the shells (Table 6).

TABLE 6.—Bacterial content of the washing solution following the washing of soiled eggs by various methods

Procedure	No. of trials	Bacteria remaining per egg, thousands			Reference
		Average	High	Low	
Bubbler washer, 10 doz., (250 ml. per egg):					
Cold water	6	768	2,257	26	
120° F. water	9	15	36	5	
Cold AFCO 2626 (½ of 1 gal.)	4	0	0	0	Winter et al. This report
120° F. AFCO 2626 (½ of 1 gal)	4	0	0	0	
Hand washed, 8 eggs, (125 ml. per egg):					
Cold water	5	422,600			Penniston and Hedrick (1944)
Cold Emulsept (0.05%)	1	10,000			
Machine scrubbed, 86 eggs, (164 ml. per egg):					
130° F. water		9,036			
140° F. water		1,100			Gunderson and Gunderson (1945)
150° F. water		492			
160° F. water		1,378			
170° F. water		410			
180° F. water		115			
Washed in blender jar, 6 eggs, (100 ml. per egg):					
Tap water	13	5,190	16,500	700	Penniston and Hedrick (1947)
Chlorine (100 p.p.m.)	16	21	130	1	
Emulsept (0.04%)	16	25	100	6	
Washed in rotating, spray, dip machine (89 ml. per egg):					
Water (120° F. 3 min.) control		29			
#6 Alkaline detergent (½ oz. 1 gal.)		169			Druckery (1953)
#3 Detergent-sanitizer (½ oz. 1 gal.)		12			

The use of a detergent-sanitizer (AFCO2626) (200 p.p.m.) in the egg washing solution destroyed all of the bacteria (Tables 5 and 6). Penniston and Hedrick (1945) reduced the number from 422,600,000 per egg in the wash water to 10,000,000 when 0.05 percent Emulsept was used in the wash water (Table 6). Penniston and Hedrick (1947) also reduced the number from 5,190,000 to 21,000 when chlorine was used in the water at 100 p.p.m. and to 25,000 when Emulsept was used at a level of 0.04 percent. Druckery (1952) reduced the number from 29,000 when water at 120° F. for 3 minutes was used to 12,000 when a detergent-sanitizer (alkaline quarternary ammonium compound, 200 p.p.m.) was added to the water (Table 6). The use of a detergent removed more bacteria from the shell than water but left them alive in the washing solution, resulting in a higher count.

Bacteria on the shell surface. A random sample of one dozen eggs were removed from each 10 dozen basket of eggs for analysis. They were broken out for bacterial analysis of shells and contents. The eggs were broken under approved sanitary practices but not under aseptic conditions. The shells were analyzed for bacterial content as previously described. They were analyzed after the eggs had been washed in cold and warm (120° F.) water and cold and warm (120° F.) detergent-sanitizer (AFCO2626). The data have been summarized in Tables 5 and 7.

Clean egg shells contained about 11,450 bacteria per gram of shell (Table 5) or about 87,000 per shell, since the average weight per egg shell as broken out was 7.6 grams. Other investigators (Table 7) have reported 5,000 to 130,000 bacteria per shell on clean eggs that had not been washed.

Washing 10 dozen clean eggs in 8 gallons of cold water in the bubbler washer for 4 minutes reduced the average bacterial content per shell about 59 percent (Table 7). When 120° F. water was used the shell count was reduced 91 percent when compared with no washing and about 80 percent when compared with washing in cold water. Gillespie et al. (1950a) did not secure a reduction in all cases when clean eggs were machine washed (Table 7). This was probably due to contamination of the machine at the time the eggs were washed.

Soiled egg shells contained an average of more than 2,162,000 bacteria per shell in the three trials conducted (Tables 5 and 7). Other investigators have reported from 230,000 to 93,333,000 per shell (Table 7), depending on the amount of dirt on the shells. In one of the two trials conducted with soiled eggs washed in cold water, the

TABLE 7.—The bacterial content per egg shell of eggs before and after various washing procedures

Washing Procedure	No. of trials	Bacteria per Egg Shell, (thousands)			Reference
		Average	High	Low	
Clean eggs:					
Not washed	3	87	117	52	
Washed in cold water	3	36	43	27	
Washed in 120° F water	3	8	15	4	
Soiled eggs:					
Not washed	2	2,063	2,162	1,965	
Washed in cold water	2	4,226	8,322	129	
Washed in 120° F. water	3	11,755	34,428	775	Winter et al. This report
Washed in cold AFCO 2626	2	272	293	15	
Washed in 120° F. AFCO 2626	2	2.5	3	2	
Clean eggs, 100		130			Haines (1938)
Machine washed 45 seconds with a brush:					
140° F. water		1,000,000			
150° F. water		700,000			Gunderson
160° F. water		495,000			and
170° F. water		350,000			Gunderson
180° F. water		250,000			(1945)
Washed in blender jar:					
Tap water	13	5,510	14,000	1,830	Penniston and
Chlorine (100 p.p.m.)	16	134	600	1	Hedrick
Ehulsept (0.04%)	16	306	1,550	6	(1947)
Machine conveyed and brush washed:					
Clean—Unwashed, control	3	102	180	46	Gillespie et al. (1950 a)
Machine washed	3	633	1,600	19	
Soiled—Unwashed, control	3	1,067	2,000	470	
Machine washed	3	849	2,100	36	
Soiled—Uncleaned	7	1,154	3,300	230	
Water	7	220	700	60	Gillespie et al.
Chlorine (1000 p.p.m.)	4	27	87	2	(1950 b)
Chlorine (5000 p.p.m.)	2	9	24	1	

resulting washed eggs contained more bacteria per shell than found on the unwashed control eggs. This was no doubt due to chance selection of eggs for washing which had more fecal material on them originally than on the unwashed soiled controls. Where such wide variations are likely to occur in bacterial analysis several samples must be analyzed before conclusive data are possible. Washing eggs in 250 ml. of cold or warm (120° F.) water per egg for 4 minutes, in the bubbler washer, left many bacteria on the egg shells. When similar soiled eggs were washed in a cold detergent-germicide (200 p.p.m.) solution the bacteria remaining on the shells were reduced about 87 percent compared with the unwashed controls (Table 7). When washed in a warm (120° F.)

TABLE 7.—The bacterial content per egg shell of eggs before and after various washing procedures—Continued

Washing Procedure	No. of trials	Bacteria per Egg Shell, (thousands)			Reference
		Average	High	Low	
Soiled—Uncleaned	2	7 350	13,000	1 700	
Water	8	691	1,900	25	
0 01 % Fixanol	2	1 335	2 500	170	
0 10 % Fixanol	2	33	63	2	
1 00 % Fixanol	2	1 4	1 7	1 1	
Hand washed in stream of solution					
Clean eggs—Not washed	3	96	140	71	
Washed in Roccal (200 ppm)	1	0			
Washed in Vel (0 5 %)	1	81			
Light dirty eggs—Not washed	3	5,433	5,900	4,500	Forsythe et al (1953)
Washed in Roccal (200 ppm)	1	0 5			
Washed in Vel (0 5 %)	1	3 1			
Dirty eggs—Not washed	3	93 333	94 000	93,000	
Washed in Roccal (200 ppm)	1	200			
Washed in Vel (0 5 %)	1	59			
Washed in conveyor, spray, brush washer					
Clean eggs unwashed		5			
Soiled, unwashed		3,487			Conner et al (1953)
Washed at 165° F		83			
Washed at 55° F		16			

Fig. 7.—Washing eggs by repeated dipping of basket in a detergent-sanitizer solution.

detergent-solution for 4 minutes the average number of bacteria remaining on the shells was reduced from 2,162,000 to 2500 or more than 99 percent. Gillespie et al. (1950b) Forsythe et al. (1953) and others (Table 7) reduced the bacteria remaining on soiled eggs similarly by washing them in detergent-germicide solutions such as chlorine compounds, Fixanol and Emulsept.

Bacteria in the egg meats. The greater the number of bacteria on the surface of egg shells, the greater the number that may be expected in the egg contents when the eggs are broken out, as shown by Wrinkle et al. (1950), Kahlenberg et al. (1952) and others. The hands of the egg breakers and the egg breaking equipment become contaminated from the dirt on the egg shells. Succeeding eggs become contaminated from those broken previously. Pieces of dirt may fall in the egg breaking cup. Bacteria on the shell surface may also penetrate into the egg if they are allowed to remain on the shell surface longer than a few hours, as shown by Miller (1954) and Feeney et al. (1954).

The bacterial content of the egg meats of the clean, soiled and soiled washed eggs are summarized in Tables 5 and 8. The bacterial content of the egg meats from clean eggs was low (less than 200 per gram) in all of the 8 analyses made. The data are in agreement with that of Forsythe et al. (1953) and Conner et al. (1953) (Table 8). The bacterial content of the egg meats from soiled eggs which had not been washed or broken out aseptically varied widely, from more than 22,000 to less than 100 per gram. Other investigators (Table 8) have also reported wide variations in similar analyses. Washing soiled eggs in a detergent-sanitizer (#115) greatly reduced the number of bacteria found in the egg meats when the eggs were broken out (Table 8). Similar data have been reported with the use of other detergent-sanitizers by Funk (1938), and Penniston and Hedrick (1947) (Table 8).

KEEPING QUALITY OF EGGS

Washed and control unwashed eggs were held three weeks at 80° F. and 66 percent relative humidity to observe possible differences in keeping quality. These holding conditions give results that are comparable to summer holding conditions on the farm and in market channels without refrigeration or in cold storage at 32° F. for five months, as pointed out by Winter et al. (1952).

The eggs were washed and dried as previously described (page 6). They were candled before holding and again at the end of the storage period. After final candling the eggs were broken out to detect any rots not detected by candling. A previous study by Winter et al. (1952) had shown that about 60 percent of the rots among cleaned eggs

TABLE 8.—The bacterial content of the egg meats from washed and unwashed shell eggs

Eggs and Treatment	No. of trials	Bacteria per gram of egg meats, (thousands)			Reference
		Average	High	Low	
Fresh eggs:					
Clean eggs, not washed	2	0.1	0.2	0	
Soiled eggs, not washed	3	12.7	22.4	1.0	Winter et al.
Soiled eggs, washed in #115 (200 p.p.m.)	3	1.3	3.3	0.2	This report
Cold storage, soiled eggs:					
Soiled, unwashed	6	93	216	17	
Soiled, washed in tap water	6	77	229	26	Funk (1938)
Soiled, washed in 1% NaOH	6	44	65	3	
Fresh eggs, artificially soiled:					
Washed in tap water	13	1,430	4,275	95	
Washed in chlorine (100 p.p.m.)	16	1	5	0	Penniston and Hedrick (1947)
Washed in Emulsept (0.04%)	16	3	20	0.5	
Cold storage eggs:					
Clean eggs, unwashed	6		4,000	1	Kahlenberg
Soiled eggs, unwashed	6		26,000	75	et al.
Soiled, machine washed	24		182,500	188	(1952)
Fresh eggs:					
Clean, unwashed		0.04			
Soiled, unwashed		0.10			Conner
Soiled, washed in cold water		0.01			et al. (1953)
Cold storage eggs:					
Clean, unwashed		0.029			
Clean, washed in cold water		0.020			Forsythe et al.
Soiled, unwashed		0.262			(1953)
Soiled, washed in cold water		0.165			

were missed by candling alone. When the eggs were broken out, they were examined for abnormal appearance of yolk and white, off odors, and fluorescence under a fluorescent or black light candler, as indications of rot. In some trials (Table 1) yolks that stuck to the inner shell membrane when the eggs were broken out were classed as rots. In other trials (Tables 2, 9 and 10) they were classified separately.

Decline in grade was calculated by assigning a value of 4 to AA grade eggs, 3 for A, 2 for B, and 1 for C. The decline in grade was calculated from the differences in the candling grades at the beginning and end of the holding period.

Washed with detergents. Seven detergents were used to wash eggs (Table 1). The keeping quality of the washed eggs was compared with unwashed controls and eggs washed in water. Eggs washed in water did not keep as well as unwashed controls. This has been pointed out previously by Winter et al. (1952). The eggs washed in detergent solutions contained 13 to 40 percent rots. The average (24 percent) was higher than for eggs washed in water (17 percent rots) (Table 9). More extensive washing and keeping quality tests were conducted with a few of the detergents. The data have been summarized in Table 9, trials 2 and 3. In both trials there was greater spoilage of eggs washed in 0.3 percent Vel than in water alone. Similar results were obtained in an earlier report by Winter et al. (1952) and with other detergents by Druckery (1953) (Table 9).

Probably detergents wash cuticle or bloom from the egg shell pores, making openings through which bacteria, from the washing solution, may gain entrance to the egg.

Washing clean eggs in 0.3% Vel solution resulted in greater spoilage than when held unwashed (Table 9, trial 3).

Washing eggs in hot (160° F.) water did not reduce spoilage more than washing in 100° F. water (Table 9, trial 2). However, washing in water at 120° F. reduced spoilage when compared with washing at 65° F. and washing in 160° F. Vel (0.3%) solution reduced spoilage when compared with washing at 100 or 65° F. (Table 9, trial 3).

The influence of temperature of the washing solution on keeping quality of eggs was summarized by the North Central Committee on Poultry Products Technology Research (1953). The results were conflicting. The new data presented (Table 9) follow the same pattern. The variable results may be due to the amount and kind of dirt on the eggs and the time elapsing between soiling and washing (page 6).

TABLE 9.—Keeping quality of eggs washed in detergents

Trial	Eggs and treatments	No. of eggs	Keeping quality, percent			Reference
			Rots	Stuck	Grade decline	
1	Clean, control	144	1			
	Soiled, control	144	4			This
	Washed in water	144	17			report
	Washed in 7 detergents	768	24			(Table 1)
2	Clean, control	1,122	2	0.4	32	
	Soiled, control	1,135	5	0.4	35	
	*Washed:					
	Water 160-180° F.	1,037	14	4.0	38	This
	Water 100-110° F.	1,092	13	3.0	39	report
	Vel (0.3 %) 100-110° F.	1,107	15	4.0	37	
	Trisodium phos. (0.3 %) 100-110° F.	1,133	13	2.0	37	
3	Clean, control	450	1	1.0	21	
	Clean, washed in Vel (0.3 %) 160° F.	450	3	2.0	48	
	Soiled, control	450	10	5.0	28	
	Soiled:					
	Washed in water 120° F.	450	11	2.0	33	This
	Washed in water 65° F.	450	22	10.0	42	report
	Washed in Vel (0.3 %) 65° F.	450	19	5.0	26	
	Washed in Vel (0.3 %) 100° F.	450	22	6.0	43	
	†Washed in Vel (0.3 %) 160° F.	450	13	4.0	33	
	Washed. Held in cold storage:					
	Washed in water (11 farms)		0.9 to 38.1			Lorenz et al.
	Washed in 2 % trisodium phosphate (8 farms)		0.0 to 11.7			(1952)
	Held under various conditions:					
	Clean, control	1,905	1.6	1.1		Winter
	Soiled, control	2,174	6.6	1.7		et al.
	Washed in water	2,146	11.4	2.8		(1952)
	Washed in 0.3 % Vel	1,821	15.3	3.7		
	Fresh eggs. Held 2 weeks:					
	Unwashed, control	401	0			
	Washed in water	463	0.7			
	Washed in 0.15 % detergent A	393	3.3			Druckery (1953)
	Washed in 0.4 % detergent B	412	2.2			

*Machine washed (Fig. 5).

†Dipped 10 times (Fig. 7)

Washed with detergent-sanitizers. Eggs were washed in 16 detergents-sanitizer solutions (Tables 1, 2 and 10). The composition of the mixtures and recommended concentration for washing eggs are listed in the Appendix pages 39-41. Most of them contained a quaternary ammonium compound as the sanitizer. The concentration recommended for most of the detergent-sanitizers was 1 tablespoon (½ oz.) per gallon or 0.3 percent. See page 42 for calculation of equivalents.

The keeping quality of the eggs washed in detergent-sanitizers was no better than when washed in detergents (Tables 1, 9 and 10). In later trials (Table 10, trials 3 and 4), in which more eggs were used, washing in detergent-sanitizers did reduce spoilage when compared with eggs washed in water or detergents. However, in no instance did washing with detergent-sanitizers improve quality over that of the unwashed soiled controls. Other investigators (Table 10) have reported similar results with the keeping quality of soiled eggs washed in detergent-sanitizers.

Probably spoilage bacteria had penetrated some of the eggs before they were washed. If so, the application of the sanitizer on the outside of the shell would be ineffective. Data have been assembled (Table 11) which show that eggs should be washed within a few hours after they are laid, if spoilage is to be kept to a minimum.

Washing eggs did not hasten the decline in grade of the eggs that did not rot (Tables 2, 9 and 10).

THE FUNCTIONAL PROPERTIES OF WASHED EGGS

Compounds for washing eggs should be colorless, odorless, tasteless and of low toxicity. Since bacteria may gain entrance to the egg contents through the shell and shell membranes, it is also possible that some of the egg cleaning solutions may gain entrance and interfere with the functional properties of the eggs. To obtain information on this point, one dozen fresh eggs were soaked for 30 minutes in cold tap water solution (0.3 percent) of detergents and detergent-sanitizers. They were then removed; dried in front of a fan; broken out; and the whites and yolks separated. The whites were tested for appearance, odor, flavor, pH, beating time and specific gravity and stability of foam.

The whites from each dozen eggs, freed from all traces of yolk, were blended for 30 seconds in a Waring blendor at reduced speed (variable vold transformer placed in circuit and set at 50) to avoid incorporation of air. The blended samples were placed in freezer jars and compared

TABLE 10.—Keeping quality of eggs washed in detergent sanitizers

Trial	Eggs and treatments	No. of eggs	Keeping quality, percent			Reference
			Rots	Stuck	Grade decline	
1	Clean, control	144	1			
	Soiled, control	144	4			This
	Washed in water	144	17			report
	Washed in 14 detergent-sanitizers	1,800	26			(Table 1)
2	Clean, control	44	0	11	63	
	Soiled, control	43	1	2	66	This
	Washed in 6 detergent-sanitizers	278	6	29	66	report (Table 2)
3	Clean, control	1,122	2	0.4	32	
	Soiled, control	1,135	5	0.4	35	
	Washed in water	1,092	13	3.0	39	
	Washed in Kleneg (0.3 %)	1,132	11	2.0	34	Winter
	Washed in Kleneg (0.3 %) and dipped in Saneg (0.06 %)	1,006	6	1.0	36	et al. (1952)
	Washed in Emulsept (0.3 %)	921	6	2.0	35	
	Washed in Kromet (0.3 %)	1,004	13	3.0	33	
4	Clean, control	450	1	1	21	
	Soiled, control	450	10	5	28	This
	Washed in water	450	22	10	42	report
	Washed in sodium hydroxide (0.3 %)	450	12	3	35	
	Clean, control	2,520	1			
	Soiled, control	1,080	5			
	Washed in water	1,080	24			
	Washed in Roccal (10 %) (0.3 %)	1,260	5			Funk (1948)
	Washed in lye (1 %)	1,260	10			
	Washed in Kleneg (0.5 %) and rinsed in Saneg (0.15 %)	720	5			
	Soiled, control	720	0			
	Washed in water	720	35			
	Washed in hypochlorite (1000 p.p.m.)	720	18			Gillespies et al.
	Soiled, control	240	1			(1950)
	Washed in water	240	5			
	Washed in 1 % Fixanol	240	1			
	Clean, control	1,905	2			
	Soiled, control	2,174	7			Winter
	Washed in water	2,146	11			et al.
	Washed in Emulsept (0.3 %)	1,702	6			(1952)
	Unwashed		0			
	Washed in water		0.7			
	Washed in detergent-sanitizer A (0.3 %)		0.0			Druckery (1953)
	Washed in detergent-sanitizer B (0.3 %)		0.2			

TABLE 11.—Influence of time bacteria are on egg shells on infection or spoilage of eggs

Study	Results	Reference
Eggs dipped in bacterial culture and held:	Infected %	
0 hours	25	Stuart and McNally (1943)
3 hours	38	
6 hours	40	
18 hours	52	
24 hours	57	
48 hours	57	
96 hours	40	
Eggs held at 41° F. for:	Infected %	Wolk et al. (1950)
6 days	11	
18 days	18	
Eggs held at 59° F. for:		
6 days	21	
18 days	26	
Eggs held at 77° F. for:		
6 days	15	
18 days	77	
Clean eggs washed after:	Spoilage %	Winter (1953)
1 day	13.2	
7 days	17.4	
Naturally soiled eggs washed after:		
1 day	11.5	
7 days	13.6	
Artificially soiled eggs washed after:		
1 day	13.0	
7 days	14.7	
Soiled eggs held:	Infected %	Miller and Crawford (1953)
Less than 14 days	<5	
14-50 days	60	
Soiled damp eggs held:		
3 days	5	
8 days	56	
Eggs dipped in Psendomonas bacteria and held before shell sterilization:	Infected %	Feeney et al. (1954)
24 hours	8	
48 hours	30	
72 hours	38	
Unsterilized	80	

for appearance, odor and flavor. The pH was measured in a Leeds and Northrup pH meter. The egg white was brought to 70° F. by placing the container in a constant temperature water bath and stirring the contents frequently. One hundred ml. of white were placed in the bowl of a Hobart household mixer (Model 3B) and beat to a finish at the highest (No. 10) speed. The finish or end point was when there was no liquid left in the bottom of the bowl and large bubbles had disappeared from the side and bottom. The specific gravity of the foam was determined by dividing the weight of a cup of foam by the weight of a cup of water. The drip (measure of unstability of foam) was measured by sliding the foam from the cup and bowl into a funnel and collecting the white that dripped into a graduated cylinder during a five minute period. The data obtained have been summarized in Table 12.

None of the samples were abnormal in appearance, odor or taste. The pH of all of them was 9.2. The beating time of samples soaked in the detergent-sanitizers was less than that of the sample soaked in water. The specific gravity of the foam was as great for eggs soaked in water as for those soaked in detergent-sanitizer solution. The drip was low in all instances, less than 1 ml., except for the control which was slightly higher.

Another trial was conducted in which the functional properties tested were extended to include meringue beating time and specific gravity and cake volume and score. The same procedure was used for the white beating test as used in the preceding trial. The procedures used for the meringue and cake tests were those used by Clinger et al. (1951). The beating test data have been summarized in Table 12 and the meringue and cake data in Table 13.

There was no difference in the appearance, odor or taste of the egg white samples in trial 2. The pH of the white was about the same as in trial 1 (Table 12) but varied a little more among samples. Forsythe (1952) also found that soaking eggs in washing solution for as long as 30 minutes did not influence interior quality as measured by Haugh units of the white, yolk index and pH. He used a detergent (0.5%), a quarternary ammonium compound (200 p.p.m.) and a combination detergent-germicide (0.5%). Forsythe reported that a trained taste panel could detect the flavor and/or odor of the products in the eggs the first few days after washing. However, they became weaker the longer the eggs were held in cold storage. Emulsept, an acid did not change the pH of the white. Some of the other products were strongly alkaline.

TABLE 12.—Influence of soaking eggs in washing solutions (0.3 percent) for 30 minutes on pH and beating properties of the white

Trial	Treatment	No. of tests	Ph			Beating time (Sec.)			Specific gravity			Drip (ml.)		
			Av.	High	Low	Av.	High	Low	Av.	High	Low	Av.	High	Low
	Control *	2	9.2	9.2	9.2	17	18	16	.11	.12	.10	1.1	1.3	0.8
	Water	2	9.2	9.2	9.2	29	31	27	.14	.15	.14	0.9	1.0	0.8
1	KDS–3	2	9.2	9.2	9.2	16	16	16	.11	.12	.11	0.9	0.9	0.9
	KDS–1	2	9.2	9.2	9.2	29	30	28	.15	.15	.14	0.8	0.8	0.8
	Emulsept	2	9.2	9.2	9.2	27	28	25	.15	.15	.15	0.3	0.3	0.3
	Thermosan	2	9.2	9.2	9.2	18	21	15	.12	.13	.12	0.8	0.8	0.8
	Control *	3	9.1	9.2	9.0	12	16	9	.15	.18	.10			
	Emulsept	4	9.1	9.2	8.9	13	19	7	.14	.15	.11			
2	Kleneg	5	9.1	9.3	8.9	15	30	3	.14	.22	.06			
	Kleneg & Saneg †	4	9.2	9.3	9.0	14	21	7	.15	.19	.12			
	Kromet	5	9.1	9.2	9.0	8	12	5	.13	.15	.11			
	Trisodium phosphate	5	9.1	9.2	9.0	9	12	5	.13	.19	.10			
	Vel	5	9.1	9.2	9.0	8	20	4	.12	.20	.08			

*Not soaked.

†Dipped in Saneg (0.06 %) momentarily.

TABLE 13.—Influence of soaking eggs in washing solutions (0.3 percent) for 30 minutes on functional properties of the white

Treatment	Meringue								Cakes							
	Beating Time				Specific Gravity				Volume				Score*			
	No. trials	Av.	High	Low	No. trials	Av.	High	Low	No. trials	Av.	High	Low	No. trials	Av.	High	Low
Control, unsoaked	4	33	53	20	3	.30	.37	.25	5	419	450	390	5	86	92	74
Trisodium phosphate	7	33	75	17	4	.33	.40	.27	7	407	450	330	7	81	96	74
Vel	7	27	87	17	4	.26	.39	.20	7	431	440	420	7	86	96	82
Emulsept	7	23	47	17	4	.29	.36	.22	7	422	440	380	7	86	90	80
Kleneg	7	42	94	17	4	.31	.41	.20	7	388	455	310	7	80	94	52
Kromet	7	18	22	17	4	.23	.25	.20	7	424	464	375	7	84	94	72
Kleneg & Saneg	7	39	80	17	4	.32	.39	.24	7	406	450	360	7	86	96	70

*Based on 100 as perfect. Appearance, texture, tenderness, moisture and flavor considered.

They also did not influence the pH of the unsoaked control eggs or those soaked in water. Therefore, soaking the eggs for 30 minutes in 0.3 percent solution of the detergents and detergent-sanitizer resulted in no absorption into the white as indicated by no change in pH of the white.

The beating test of the white was quite variable among samples receiving the same treatment. It varied more in this respect than among treatments (Table 12, trial 2). Therefore, one must assume that the soaking treatment did not influence the beating properties of the white. The same is true of the specific gravity of the foam. The latter is influenced by the beating time, end point, or finish of the white. The technique needs to be improved so that closer results may be obtained when different samples from the same lot are tested.

The meringue tests varied widely among different samples receiving the same treatment (Table 13). One must assume from the data presented that the soaking of the samples did not interfere with functional properties as measured by beating properties of the white.

The final and most important measure of the functional properties of egg white is its performance in angel food cakes. All the cakes were satisfactory as measured by cake volume and score (Table 13). It appears that meringue and cakes prepared with white from eggs soaked in Kleneg were not quite as good as when prepared with white from eggs soaked in the other solutions. However, more trials would be necessary to show that the differences are real.

DISCUSSION

The data (Table 1) indicate that simple detergent compounds are as satisfactory as more complex mixtures for cleaning eggs. For instance, trisodium phosphate and sodium metasilicate proved about as satisfactory as any of the 18 trade name detergent and detergent-sanitizers tested. The combining of sanitizers with detergents to form detergents-sanitizer mixtures did not reduce the cleaning efficiency of the detergents. Care needs to be exercised in formulating mixtures so that the compounds are compatible with each other, as pointed out by Botwright (1953) and Druckery (1953). Alkaline products are generally formulated for washing eggs because of the alkaline (calcium carbonate) nature of the shell. Acid products are more destructive to shell composition and are used up more quickly by combining with dissolved shell. Detergent-sanitizers containing a quarternary ammonium compound are more widely used than those containing chlorine because they maintain their strength longer as shown by Penniston and Hedrick (1945) Botwright (1953) and Druckery (1953).

The data (Table 4 and Figure 6) show that the egg washing solution (0.3%) should be changed frequently. Botwright (1953) has pointed out that the cleaning efficiency becomes ineffective before the sanitizing power is lost. At least, this is true when a product such as No. 115 is used.

Machine washing of eggs was not as thorough as hand washing. A rubbing effect is necessary to remove the dirt and stain from many of the eggs. The machine (Fig. 5) equipped with a brush and blower did about as well as hand washing (Table 3), if the eggs were pre-soaked in a detergent-germicide and the same solution used instead of water in washing the eggs. Machine cleaning may contaminate rather than reduce the number of bacteria on eggs unless the machine is thoroughly cleaned after each use as shown by Gillespie et al. (1950a), and Miller et al. (1950).

Washing eggs removes many bacteria from the shell but also leaves many. Therefore, it would seem that a sanitizer should be used with the detergent or immediately following it and in sufficient concentration to kill the bacteria remaining on the shell. There is also evidence, Winter et al. (1952) that the eggs should not be rinsed with water after washing in a detergent-germicide solution. As the eggs dry the germicide becomes more concentrated. It has a longer time to act, if not washed off. The time of action and the concentration of the germicide are highly important factors in the destruction of bacteria.

There is evidence (Table 7) that even clean eggs contain many bacteria on the shell surfaces at the time of gathering. There is also evidence (Table 11) that the longer bacteria are left on eggs, the warmer the temperature and the damper the surroundings the greater the infection and spoilage that may be expected. Preliminary unpublished data from this laboratory as well as published data (Table 7) and a report by Botwright (1953) show that washing eggs in solutions containing a quarternary ammonium compound (200 p.p.m.) will destroy bacteria which cause black and green rot spoilage of eggs. Many large poultry farmers may, in the not too distant future, wash all of their eggs the day gathered in a warm detergent-germicide solution (200 p.p.m.) and allow the solution to dry on the eggs. The practice should destroy bacteria on the shells before they penetrate the eggs; partially close the egg shell pores; and form a surface barrier against later contamination from the air, handling and packing material.

The Northeast Poultry Producers Council (1954) offers a service for testing detergent-sanitizers and approving or rejecting them for egg washing. The approved list is revised from time to time. A copy may

be obtained by writing to the Association. Most of the approved detergent-sanitizers are alkaline, contain a quarternary ammonium compound and are formulated to contain 200 p.p.m. of germicide when used at a recommended concentration of 1 tablespoon per gallon (0.3 percent solution) for sanitizing eggs.

SUMMARY

The addition of detergents to water facilitated the removal of dirt and stain from eggs.

The addition of germicides to detergents at 5 to 10 percent levels did not reduce their efficiency for removal of dirt and stain.

Three-tenths percent concentration of most of the detergents and detergent-germicides was as effective as 0.6 prcent for removal of dirt and stain.

Soaking soiled eggs for 10 minutes in egg washing solutions facilitated dirt and stain removal.

Hand washing removed more dirt and stain than machine washing. Machines equipped with a rubbing device removed more dirt and stain than those provided with a sprayer or bubbler attachment.

Detergent-sanitizers, detergents, and water were most effective in the order named for reducing the number of bacteria on egg shell surface and in the egg contents, when the eggs were broken out.

Eggs washed within a few hours after gathering kept better than those washed after holding several days.

A concentration of 200 p.p.m. of sanitizer in an egg washing solution is satisfactory for the destruction of bacteria, on egg shells, which cause green and black rots.

Soaking eggs as long as 30 minutes at 100° F. in 0.3 percent solutions of 2 detergents and 4 detergent-sanitizers tested did not affect the white as measured by appearance, odor, flavor, pH, beating properties and value for making angel food cakes.

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APPENDIX

DETERGENTS, DETERGENT-SANITIZERS AND SANITIZERS*

AFCO 2626. An alkaline detergent-sanitizer containing 5% alkyl tolyl methyl trimethyl ammonium chlorides (Hyamine 2839), 15% sodium carbonate, 20% sodium metasilicate and 60% inert and special detergent ingredients. Recommended use 1/3 oz. per gallon. Alex C. Ferguson Co., Philadelphia 48, Pa.

Ahcogent. A detergent-sanitizer containing 5% para di-isobutyl phenoxy ammonium chloride (Hyamine 1622). Recommended use ½ oz. per gallon. Apothecaries Hall Co., Waterbury, Conn.

Calgon. A detergent consisting of sodium hexametaphosphates. Calgon, Inc., Pittsburgh, Pa.

Clorox. A liquid detergent-sanitizer containing 5.25% sodium hypoclorite. Recommended use ½ oz. per gallon (200 p.p.m. available chlorine). Clorox Chemical Co., Oakland, Cal.

D–40. A detergent composed of 40% alkaryl sulfonate and 60% sodium sulfate. Oronite Chemical Co., 600 S. Michigan Ave., Chicago 5, Ill.

Diokem. A detergent-sanitizer containing para-chlorobenzyl dimethyl tetramethyl butyl phenoxy ethoxy ethyl ammonium chloride sodium carbonate and duodecyl mercaptan polyox ethylene glycol. Recommended use 1/5 oz. per gallon (100 p.p.m.). The Diversey Corp., 53 W. Jackson Blvd., Chicago 7, Ill.

Dreft. A detergent containing a sodium alkylbenzene sulfonate. Proctor and Gamble Co., Cincinnati, Ohio.

Durogent. An alkaline detergent-sanitizer containing 5% di-isobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride. Recommended use 1 oz. per gallon. Apothecaries Hall Co., Saterbury, Conn.

Emulsept. A liquid acid detergent-sanitizer containing 10% N (higher acyl esters of colamino formylmethyl) pyridinium chloride. Recommended use ½ oz. per gallon. Emulson Corp., 59 E. Madison St., Chicago, Ill.

Fixanol C. A cationic detergent-sanitizer containing 75% cetyl pyridinium chloride. Imperial Chemical Industries Ltd., Homebush, N.S.W., Australia.

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*Composition of products at time tested.

Hyamine 2389. Sanitizer consisting of alkyl tolyl methyl trimethyl ammonium chlorides. Rohm and Haas Co., Washington Square, Philadelphia 5, Pa.

KCD–1. An acid detergent-sanitizer containing alkyl dimethyl benzyl ammonium chloride. Recommended use 1 oz. per gallon (200 p.p.m.). Klenzade Products Co., Beloit, Wis.

KDS–1. An alkaline detergent-sanitizer containing 10.8% para-di-isobutyl phenoxy ethoxy, ethyl dimethyl benzyl ammonium chloride. Recommended use ¼ oz. per gallon (200 p.p.m.). Klenzade Products Co., Beloit, Wis.

KDS–3. An acid detergent-sanitizer containing 7.7% alkyl dimethyl benzyl ammonium chloride. Recommended use 1/3 oz. per gallon (200 p.p.m.). Klenzade Products Co., Beloit, Wis.

Kleneg. An alkaline detergent-sanitizer containing 5% trimethyloctadecynl and trimethyloctadecadienyl ammonium chlorides (Saneg), tetrasodium pyrophosphate, sodium carbonate, trisodium phosphate and polyethylene-glycol ester of oleic acid. Recommended use ¾ oz. per gallon. Armour & Co., 1425 W. 42nd. St., Chicago 9, Ill.

Kromet. A detergent-sanitizer containing chloramine T. Recommended use 1 oz. per gal. Wyandotte Chemicals Corp., Wyandotte, Mich.

Lye. A detergent-sanitizer containing 76% sodium hydroxide. The Drackett Co., Cincinnati, Ohio.

Nacconol NR. An anionic detergent-sanitizer containing 40% active organic sulfonate and 60% sodium sulphate. National Aniline Division, Allied Chemical and Dye Corp., 40 Rector St., New York 6, N. Y.

No. 5. An alkaline detergent-sanitizer containing 10% di-isobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride (Hyamine 1622), 5% alkyl aryl polyether alcohol, 30% sodium metasilicate and 55% tetrasodium pyrophosphate. Recommended use ¼ oz. per gallon (200 p.p.m.). Formulated by Rohm and Haas Co., Washington Square, Philadelphia 5, Pa.

No. 115. An alkaline detergent-sanitizer containing 10% alkyl tolyl methyl trimethyl ammonium chlorides (Hyamine 2389), 5% triton X-100, 0.05% Dow-Corning anti-foam A, 15% sodium metasilicate,

19.95% soda ash and 50% sodium tripolyphosphate. Recommended use ½ oz. per gallon (200 p.p.m.). Formulated by Rohm and Haas Co., Washington Square, Philadelphia 5, Pa.

Roccal. A sanitizer solution containing 10% alkyl-dimethyl benzyl-ammonium chlorides. pH 7. Recommended use ¼ oz. per gallon (200 p.p.m.). Sterwin Chemicals, 1450 Broadway, New York 18, N. Y.

Saneg. A liquid sanitizer containing 25% trimethylocta-decfnyl and trimethyloctadeca-dienyl ammonium chlorides. Recommended use 1/5 oz. per gallon (200 p.p.m.). Armour and Co., 1425 W. 42nd. St., Chicago 9, Ill.

Salute. A de-staining detergent. Recommended use 3/10 oz. per gal. Wyandotte Chemicals Corp., Wyandotte, Mich.

Sanisuds. A detergent-germicide containing a quarternary ammonium compound and a non-ionic detergent. Recommended use 0.4 oz. per gallon. Columbia Chemical Co., 154 E. Erie St., Chicago 11, Ill.

Santomerse. A detergent containing an alkyl aryl sulfonate. Monsanto Chemical Co., St. Louis, Mo.

Thermosan. A liquid detergent-sanitizer containing a quarternary ammonium salt and non-ionic detergents. Recommended use 1/5 oz. per gallon. The Borden Co., Tykor Products Division, 350 Madison Ave., New York 17, N. Y.

Tri-Bac. An alkaline detergent-sanitizer containing 3% di-isobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride, 15% trisodium phosphate, 20.7% sodium carbonate, and 61.3% inert ingredients. Recommended use 9/10 oz. per gallon (200 p.p.m.). Wyandotte Chemical Corp., Wyandotte, Mich.

Vel. An alkaline detergent containing a sulfonated mono-glyceride. Colgate-Palm-Olive Peet Co., 105 Hudson St., Jersey City 2, N. Y.

Some Approximate Weight, Measure Percent and Parts Per Million (p. p. m.) Equivalents

1 gallon = 8 pints = 16 cups = 3785 milliliters (ml.) (water)
= 3.8 liters (l.) = 3785 milliliters (ml.)
= 8.3 pounds (lbs.) = 3785 grams (gms.)

1 pound = 16 ounces (oz.) = 454 grams

1 ounce = 2 tablespoons (level) = 6 teaspoons
= 30 grams = 30 ml.

10 percent (%) = 100,000 p. p. m.

1 percent = 10,000 p. p. m.

0.1 percent = 1,000 p. p. m.

mg. per kilogram (kg.) = p. p. m.

grams per ton = p. p. m.

grams per ton = micrograms (mcg.) per pound

1 gram = 1,000 milligrams
= 1,000,000 micrograms (mcg.)
= 1,000,000,000 millimicrograms (mug.)